DOCUMENT RESUME

ED 372 969 SE 055 049

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TITLE Current Reform Efforts in Mathematics Education. ERIC/CSMEE Digest.
INSTITUTION ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.
SPONS AGENCY Office of Educational Research and Improvement (ED), Washington, DC.
REPORT NO EDO-SE-94-5
PUB DATE Oct 94
CONTRACT RR93002013
NOTE 4p.
AVAILABLE FROM ERIC/CSMEE, 1929 Kenny Road, Columbus, OH 43210-1080 (Free).
PUB TYPE Information Analyses - ERIC Clearinghouse Products (071)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Curriculum Development; *Educational Change; Elementary Secondary Education; *Inservice Teacher Education; *Mathematics Curriculum; *Mathematics Education; Teacher Education Programs; *Technology
IDENTIFIERS ERIC Digests; *Reform Efforts

ABSTRACT

The current reform effort in mathematics education has its roots in the decade of the 1980's and the national reports that focused attention on an impending crisis in education, particularly in mathematics and science. Within this context, dozens of individual reform efforts have been initiated in recent years. Many have focused on the development of new curricula, others on teacher enhancement, some on both. Still others have taken the use of technology in mathematics instruction as their central theme. The projects listed in this digest are but a small sample of current efforts, but they serve to illustrate the diversity of programs nationwide. Programs discussed in this digest include: Connected Mathematics Project, Adventures of Jasper Woodbury, Maneuvers with Mathematics, Mathematics in Context, Quantitative Reasoning Project, University of Chicago School Mathematics Project, Atlanta Math Project, Teaching to the Big Ideas, Integrating Science and Mathematics Teaching for Middle School Underrepresented Students, Math Matters, New York City Mathematics Project, Project IMPACT, Quantitative Understanding--Amplifying Student Achievement and Reasoning; Cognitively Guided Instruction, Delaware Teacher Enhancement Project, Math Learning Center, Calculator and Computer Precalculus Project, Computer Intensive Algebra, Empowering Teachers in Computer-Intensive Environments, Geo-Logo, Graphing Calculator-Enhanced Algebra Project, and Calculus Curriculum Project. (Author/MKR)

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ERIC CSMEE Digest

Clearinghouse for Science, Mathematics, and Environmental Education EDO-SE-94-5 October 1994

Current Reform Efforts in Mathematics Education

Thomas G. Edwards

The current reform effort in mathematics education has its roots in the decade of the 1980s and the national reports that focused attention on an impending crisis in education, particularly in mathematics and science (e.g., *An Agenda for Action*, 1980; *A Nation at Risk*, 1983; *A Report on the Crisis in Mathematics and Science Education*, 1984). It received further impetus with the publication by the National Council of Teachers of Mathematics (NCTM) of *Curriculum and Evaluation Standards for School Mathematics* (1989) and *Professional Standards for Teaching Mathematics* (1991). The Mathematical Sciences Education Board (MSEB, 1990) urges that school mathematics programs be revised and updated to reflect the NCTM *Standards*, develop students' mathematical power, use calculators and computers throughout, feature relevant applications, and foster active student involvement.

Within this context, dozens of individual reform efforts have been initiated in recent years. Many have focused on the development of new curricula, others on teacher enhancement, some on both. Still others have taken the use of technology in mathematics instruction as their central theme. The projects listed below are but a small sample of current efforts, but they serve to illustrate the diversity of programs nationwide.

Curricular Reform Projects

The *Connected Mathematics Project (CMP)* at Michigan State University is a five-year National Science Foundation (NSF)-funded project for the development of a middle school mathematics curriculum rich in connections. Students solve problems by observing patterns and relationships, thereby enhancing their understanding of mathematics. Natural extensions involve conjecturing, testing, discussing, verbalizing, and generalizing. In addition to student materials, *CMP* is developing teacher materials designed so that teachers can learn directly from their use and assessment materials that are extensions of the learning process.

The Adventures of Jasper Woodbury is a series of four problem-solving videodisks developed by the Cognition and Technology Group at Vanderbilt University, supported in part by grants from NSF and the James S. McDonnell Foundation. The theory underpinning this work emphasizes the importance of developing instruction in meaningful, active contexts and is in step with the *Standards* recommendation that problem-solving applications should drive instruction (NCTM, 1989).

The University of Illinois at Chicago NSF-funded project, *Maneuvers With Mathematics (MWM)*, has produced a series of student lab books to supplement or replace components of the middle grades mathematics curriculum. *MWM* presents thought-provoking, original problems that utilize manipulative materials. Students investigate a series of carefully sequenced activities aimed at hands-on discovery of mathematical concepts that often integrate mathematics with other content areas.

Mathematics in Context has been funded by NSF to create a comprehensive mathematics curriculum for the middle grades that reflects the content and pedagogy suggested by the NCTM *Standards* (1989, 1991). The University of Wisconsin—Madison and the Freudenthal Institute at Utrecht University are collaborating with middle school mathematics teachers to develop the curriculum. These materials will support teachers' efforts to connect students' previous knowledge with new ideas, connect conceptual and procedural knowledge, and connect mathematics with other fields of human endeavor.

The *Quantitative Reasoning Project (QRP)* at San Diego State University is an NSF-funded project investigating the development of students' algebraic reasoning in the middle grades following instruction that emphasizes quantitative reasoning. *QRP* has objectives in three domains: students' cognitions, teachers' cognitions, and materials development. *QRP* will identify areas of the middle school mathematics curriculum that can be modified to allow for direct instruction in quantitative reasoning and will develop activities and problems to support such instruction.

Since 1983, the *University of Chicago School Mathematics Project (UCSMP)*, funded by Amoco, General Electric, and the Carnegie Corporation, has developed a six-year secondary mathematics curriculum encompassing a broad scope of content and emphasizing real-world applications. In focusing on both procedural and conceptual knowledge, student understanding is developed in four domains: skills, concepts, applications, and representations. Reading mathematics is stressed for all students, and appropriate use of computers and graphing calculators is presumed. *UCSMP* is currently developing a K-6 curriculum structured as a helix, with skills and concepts developed over time and revisited in varying contexts. The materials assume the use of calculators and manipulatives.

Teacher Enhancement Projects

Some teacher enhancement projects are aimed at all mathematics teachers of particular grade levels, while others target teachers of specific student populations, such as minority students or groups that have traditionally been underrepresented in higher mathematics courses. Many projects target teachers who work in urban classrooms.

Projects With a General Focus. The *Atlanta Math Project (AMP)* at Georgia State University is an NSF-funded project operating in 13 school systems in the metropolitan Atlanta region. *AMP* provides teachers with experiences that facilitate their construction of knowledge about teaching and learning mathematics consistent with the NCTM *Standards*. Project activities include summer professional development; on-site school-year support in the form of planning, teaching, and debriefing sessions; and peer mentoring.

Teaching to the Big Ideas (TBI) is a four-year professional development project involving staff from Education Development Center, Mt. Holyoke College, and the Technical Education Research Center (TERC), in which teachers address the big ideas—the central organizing principles—of mathematics. During the first two years of the project, *TBI* will engage participants through summer institutes, bi-weekly after-school meetings, and classroom visits. The last two years will feature summer institutes, as well as a year-long course geared toward the development of participants as teacher leaders.

Projects Targeting Specific Populations. California State Polytechnic University at Pomona, in cooperation with school districts in Southern California, is conducting a teacher enhancement program called *Integrating Science and Mathematics Teaching for Middle School Underrepresented Students*. This three-year project will offer hands-on instruction that integrates science, mathematics, and teaching methods consistent with the NCTM *Standards*, the new science standards, and the appropriate California state frameworks.

Math Matters is an NSF-funded four-year grant to the California Department of Education to improve the mathematics achievement of Chapter 1 and migrant students in the upper elementary grades. *Math Matters* is a comprehensive professional

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development program which encourages teachers to share experiences with their peers. The major components of the project are mathematics for the professional growth of participants, mathematics for the classroom, management and content strategies, and assessment practices.

The *New York City Mathematics Project (NYCMP)* is a K-12 staff development project that responds to the critical problem of providing a quality mathematics program for all students in urban classrooms. *NYCMP* seeks to produce a leadership network of teachers, exemplary environments for teaching mathematics in urban classrooms, and a support system for ongoing staff development. The four stages in the staff development model used by *NYCMP* are becoming aware of the need to change, making major changes in teaching practice, becoming a teacher leader, and finally, teaching in the project.

Project IMPACT is a cooperative between the University of Maryland at College Park and the Montgomery County Public Schools. Partially funded by IBM, the project is developing a model for elementary mathematics instruction that enhances student understanding and supports teacher change in predominantly minority schools. *IMPACT* is a school-based project that includes a summer in-service program, on-site mathematics specialists, innovative classroom materials, and a common mathematics planning period for all teachers of a given grade level in each school.

The Learning Research and Development Center at the University of Pittsburgh has undertaken the *Quantitative Understanding: Amplifying Student Achievement and Reasoning (QUASAR) Project* in response to the related crises of low levels of student participation and inadequacy of student performance in mathematics. *QUASAR* addresses the needs of schools serving economically disadvantaged children, using a coherent set of general principles as guides for reform while recognizing the importance of tying reform efforts to local conditions. Instructional practices at all sites feature increased emphasis on mathematical discourse, the application of mathematics to problems that are meaningful to students, and the use of physical and mental models to provide concrete grounding for abstract principles. *QUASAR* encompasses curriculum development and modification, staff development and ongoing teacher support, classroom and school-based assessment design, and outreach to parents and the community.

Projects Involving Both Curriculum Reform and Teacher Enhancement

At the University of Wisconsin Center for Educational Research, *Cognitively Guided Instruction (CGI)*, partially supported by an NSF grant, structures workshop environments in which teachers synthesize findings of research on children's mathematical thinking to inform their teaching. As a result, each teacher can construct a mathematical learning environment that fits her or his own teaching style, knowledge, beliefs, and students.

At the University of Delaware, an NSF-funded project is developing a model for implementing the NCTM *Standards*. Project goals are to develop mathematical power in teachers and assist them in implementing *Standards*-based curricula in their classrooms. To achieve these goals, the *Delaware Teacher Enhancement Project* seeks to enhance teachers' knowledge of mathematical content, pedagogy, and curriculum, and to help them develop a supportive school environment.

The primary goals of the *Math Learning Center (MLC)* at Portland State University are to develop curriculum materials and workshops for middle school teachers who seek to change the way mathematics is learned in their classrooms. *MLC* materials emphasize visual thinking, exploration, and experimentation. Workshops typically engage teachers in hands-on activities that model independent investigation, small group cooperative learning, and whole class discussion.

Projects Focused on Technology

The *Calculator and Computer Precalculus (C^2PC) Project* at Ohio State University has produced a curriculum based on computer/calculator-generated graphs. Students use the power of visualization to solve realistic, interesting applications through exploration and experimentation. Because technology enables interactive instruction that casts teachers in nontraditional roles, C^2PC conducts workshops to assist teachers in moving beyond transmission of knowledge to facilitation of learning.

The *Computer Intensive Algebra (CIA) Project* has capitalized on opportunities for improving instruction in algebra using computers and calculators. With support from NSF grants to the University of Maryland and Pennsylvania State University, *CIA* has developed a computer-based algebra curriculum featuring models and representations of algebraic ideas, variables and functions as unifying concepts, and a balance between conceptual and procedural knowledge in algebra instruction.

Because *CIA* de-emphasizes routine skills in favor of computer-based explorations, teachers must assume a variety of unfamiliar roles. *Empowering Teachers in Computer-Intensive Environments* will construct a series of courses and practica to prepare teachers to implement computer-intensive curricula by increasing their mathematics content knowledge through a computer-intensive course, developing their ability to assess and analyze student understanding in technology-rich learning environments, assisting them to conduct research in their own classrooms, and focusing their attention on teaching/learning issues in computer-intensive learning environments.

One result of an NSF-supported cooperative project among SUNY at Buffalo, Kent State University, TERC, and Southeastern Massachusetts University is *Geo-Logo*, a new Logo environment that emphasizes in-depth exploration of meaningful mathematical problems, supports construction of the abstract from the visual, connects different representations, and encourages procedural thinking to undergird conceptual understanding.

The *Graphing Calculator-Enhanced Algebra Project*—funded by NSF, the Interlochen Arts Academy, and Texas Instruments—starts with the premise that students have access to graphing calculators and teachers have comparable technology for in-class demonstrations. The curriculum materials feature fewer problems considered in greater depth, emphasis on small group work, analysis of graphical representations, and development of mathematical concepts in real-world contexts accessible to high school students.

The Oregon State University *Calculus Curriculum Project* has developed a curriculum that uses supercalculators (e.g., HP-48SX) and emphasizes multiple representations of functions, graphical interpretations, conceptual understanding, real-world applications, mathematical modeling, and the intelligent use of technology with full awareness of its limitations.

Systemic Initiatives

In 1992, NSF began funding Statewide Systemic Initiatives (SSIs) for the purpose of improving school mathematics and science education. Some SSIs exhibit elements of both curriculum reform and teacher enhancement (e.g., the Systemic Initiative for Montana Mathematics and Science), while others are primarily teacher enhancement projects (e.g., Ohio's Project Discovery). Beginning with the 1993-94 school year, NSF is funding Urban Systemic Initiatives (USIs), to improve mathematics and science education under the special circumstances of urban schools.

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OERI This digest was funded by the Office of Educational Research and Improvement, U.S. Department of Education under contract no. RR-93002013. Opinions expressed in this digest do not necessarily reflect the positions or policies of OERI or the Department of Education.

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